Performance and emission characteristics of a DI Diesel Engine using Methyl Ester of Groundnut oil as a fuel

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ABSTRACT

Nowadays petroleum based fuels in worldwide not only make depletions in the conventional sources but also increase the level of air pollution .The increase in level of pollution makes the idea of using alternative fuels that cause less pollution rates than by petroleum products.This paper confines the study of using the biodiesel as the alternative fuel to petroleum products .Experiments are conducted where the methyl ester from the peanut seeds are used in the preparation of the biodiesel through the Trans-esterification process . Here the fatty acid methyl ester after being washed are blended with diesel as in the case of B50 (50%biodiesel + 50% diesel).The performance and characteristic tests are performed in the four stroke, single cylinder water cooled engine. From this study it is found that the optimum performance is carried in the b50 blend fuel. Here the properties of the fuels are founded such as flash point, viscosity, fire point and calorific values repectively.With this investigation, the report claims to show that the values of the CO, HC values are came to be lowered in the case of biodiesel operations when compared with that to the diesel operation. Here the values of the NOx from the side of biodiesel tends to be increased when compared to the NOx levels of the diesel combustion.

Keywords—groundnut oil; biodiesel;performance; emission

I INTRODUCTION

Energy is the main source to support our life and also in the economical way. The world's economic growth runs on the growth of energy. Fossil fuels like oil, coal, natural gas occupies about 86% of energy requirement. With increasing population in the world, the demand for the consumption of natural resources keeps increasing, India being the second largest country in the world and with the demand of energy usage keeps increasing dramatically. These fossil fuels play a vital role in increasing pollution contents at greater concern. Pollution affects the natural climate at higher state. The stock of petrochemical product is limited and un-sustainability for energy is increasing in the world. Petrochemical products are highly responsible for local and global environment pollution. The causes from the usage of fossil fuels like acid rain,global warming, increasing the NO_x contents, changing the air contaminant levels and so on. Since the usage of motor vehicles and other heavy machines that runs with the combustion of fossil fuels, the global warming keeps on increasing, causing the way to make the holes on the ozone layer. This causes serious health issues including the skin ccancer where due to the radiations that enter directly from the sky. Therefore, it is necessary to search alternative fuels. Thus here the implementation of ideas towards the use of alternative fuels makes the better way for reduction of some levels in the affects that the fossil fuels make. Many journals and reports are made towards the way of alternative fuels. Alternative fuels such as the biomass, biodiesel, electricity, oils from the vegetable wastes and so on.

Biodiesel is considered to be the most promising alternative fuel for diesel engines. Biodiesel contains approximately 10-15% of oxygen by weight is a bio-degradable, non-toxic and renewable fuel and has similar combustion behavior to diesel fuel. For the biodiesel production, oils or fats reacts with alcohols (commonly ethyl or methyl alcohol). This chemical reaction requires alkali or acid catalysts is known as esterification (the

reaction of the free fatty acids with an alcohol to produce an ester of a fatty acids) or transesterification process (the reaction of triglycerite with an alcohol to produce a mixture of fatty acid alcohol ester). Here the catalyst, potassium hydroxide is preferred. In the case of using the alkali catalysis, the transesterification process is much faster than the acid catalyzed transesterification process. Glycerin, a byproduct of the above reaction by using the precipitation tank separated from the sample by centrifugation. In selecting the feedstock for biodiesel production, two crucial factors must be taken into account, namely the amount of the raw material and the cost of production.

The raw material price accounts 70-90% of the total biodiesel cost.To produce biodiesel,vegetable oils of edible origin were treated as one of the potentiel feedstocks once. Bio-fuels might contribute to meet the future energy supply demands as well as helping to the reduction of greenhouse gas emissions(GHG).

For obtaining the characteristic values of the petroleum products, here normally biodiesel is blended with these petroleum products such that here the efficiency can be increased along with the reduction of the emission contents. Biodiesel can be blended and used in many different concentrations. Much of the world uses system known as the "B" factor to state the amount of biodiesel content in any fuel mix. Normally blending of biodiesel are done at the rate of B2, B5, B20, B50, B100 in various parts of the world. With these variation in the amount of blend, the performance characteristics, rates, efficiency and many other factors are varied simultaneously. Blends of 20% biodiesel and lower can be used in diesel equipment with no, or only minor modifications, although certain manufacturers do not extend warranty coverage if equipment is damaged by these blends.

II MATERIALS AND METHOD

A. *Transesterfication*

Transesterification of natural glycerides with methanol to methylesters is a technically important reaction that has been used extensively in the soap and detergent manufacturing industry worldwide for many years. Almost all biodiesel is produced in a similar chemical process using base catalyzed transesterification as it is the most economical process, requiring only low temperatures and pressures while producing a 98% conversion yield. The transesterification process is the reaction of a triglyceride (fat/oil) with an alcohol to form esters and glycerol. A triglyceride has a glycerine molecule as its base with three long chain fatty acids attached. The characteristics of the fat are determined by the nature of the fatty acids attached to the glycerine. The nature of the fatty acids can, in turn, affect the characteristics of the biodiesel.

During the esterification process, the triglyceride is reacted with alcohol in the presence of a catalyst, usually a strong alkaline like sodium hydroxide. The alcohol reacts with the fatty acids to form the mono-alkyl ester, or biodiesel, and crude glycerol. In most production, methanol or ethanol is the alcohol used (methanol produces methyl esters, ethanol produces ethyl esters) and is base catalyzed by either potassium or sodium hydroxide. Potassium hydroxide has been found more suitable for the ethyl ester biodiesel production, but either base can be used for methyl ester production.

B. *B.Blending process*

The blending of groundnut oil (Peanut oil) fuel that is being use is B50. This is the fuel that we can get from ordinary grocery store.

We will be also using a diesel engine to test the fuel for performance in term of brake power and engine emission. The alternative fuel will also be prepared accordingly. The Groundnut oil distillate that being used is ablending of groundnut oil distillate with other fuel such as diesel and the mixture would bring the viscosity close to diesel fuel specification. Performance curves will be developed for a diesel engine fuel by B50. The engine to be tested shall be representative of the manufacturer's production units, and the fuel used shall conform to the manufacturer specifications. The engine will be loaded for tests with an oil cooled eddy current absorption dynamometer 0%, 25%, 50%, 75% and 100% load. Dynamometer load being controlled using a controller. The throttle will then be increased until the engine reaches full open throttle. Once full open throttle is obtained, a load will be applied to the engine. Once engine speed and torque measurements have been stable for two minutes, all data is collected for two minutes. The load on the engine then being increased, while full open throttle is maintained, until the engine speed decreases to a desired level.

I. III EXPERIMENTAL SETUP AND MEASUREMENT

The experiments were conducted in Kirloskar AV1 make water cooled four stroke diesel engine.The rated power of the engine is 5.20 kW running at a constant speed of 1500 rpm. The schematic view of the experimental setup is given in the Figure 1. Engine is connected with the swinging field electrical generator with load bank. The engine specification is given in the table 2.2. AVL-444 gas analyzer is used to measure the HC, CO and NOx emissions. The smoke opacity was measured using AVL-437 Hatridge smoke meter. The exhaust gas temperature was measured using K-type thermocouples. Piezoelectric pressure sensor was used to measure the in-cylinder pressure at every crank angle (CA) by a charge amplifier transducer in the range of 0-100 bar.

ENGINE SPECIFICATIONS	
Type	Kirloskar AV 1, Water cooled, Four Stroke
Number of cylinders	Single
Bore	87.5 mm
Compression ratio	17.5:1
Maximum power	5.20 kW
Speed	1500 rpm
Dynamometer	Electrical
Injection pressure	200 bar

Table 1: Engine Specification

Parameters such as engine speed, fuel flow, and emission characteristics were obtained from the data acquisition system connected to the engine. Brake thermal efficiency, brake power, and specific fuel consumption were evaluated from the above parameters to study the performance of the engine.

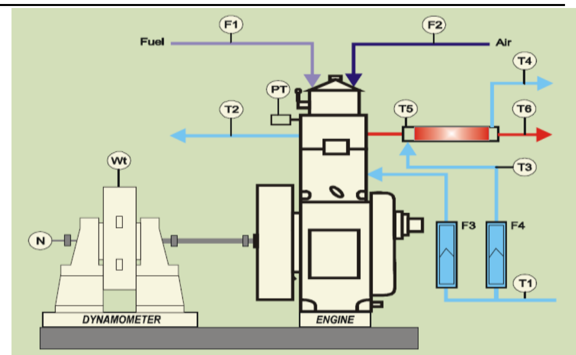

Fig 1: Layout of diesel engine

Temperature	Water flow liter per hour
Engine cooling water T1	Fuel line F1
Engine cooling water outletT2	Air inlet F2
Calorimeter water inlet T3	Engine cooling water 200lph F3
Calorimeter water outlet T4	Calorimeter water 100lph F4
Calorimeter exhaust gas in T5	Pressure transmitter PT
Calorimeter exhaust gas out T6	Crank angle encoder N

Table 2: Description

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I. IV TEST PHASES

The various phases of tests on the above setup are carried out on the following phases.

1. Running the engine with diesel alone.
2. Running the engine with different blend ratios with Biodiesel (Esterified Groundnut oil) and diesel as follows,

- 50:50 (Esterified Groundnut oil: Diesel).
- 100 - Esterified Groundnut oil.

II. V RESULT AND DISCUSSION

A. A.Properties of Fuels

The properties are more important to run the engine and the properties for groundnut oil, diesel, biodiesel that taken from the groundnut. The properties like viscosity, density, and calorific value, flash and fire point are given below

	Ground nut oil	B100	B50	Diesel
Kinematic viscosity @40°C in cst	34.1	4.8	4.07	4.65
Flash point(°C)	249	173	57	35
Fire point(°C)	255	181	65	44
Gross calorific value kJ/kg	4200	36154	38,487	42500
Density in kg/m³	921.4	910	874	840

Table 3: Properties of fuels

B. Preformance characteristic

a. Brake thermal efficiency

Brake thermal efficiency (BTE), commonly known as fuel conversion efficiency that replicates the percentage of fuel energy converted into useful energy. If different fuels are to be compared for the same engine, Brake thermal efficiency is the best suitable parameter instead of Specific fuel Consumption (SFC). The blends of B50 (50% Biodiesel and 50%Diesel) and B100 (100% Biodiesel) is slightly lower than that of diesel in full load condition.

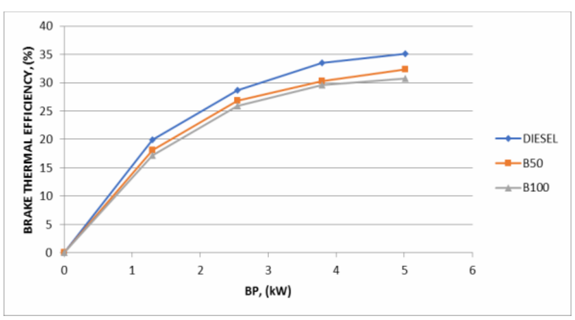

Fig 2: Brake thermal efficiency against brake power

C. Emission characteristic

a. Smoke

Smoke is the visible product of diesel engine emission. The comparison of Smoke of B50 (50% biodiesel and 50% diesel), B100 (100% biodiesel) and petroleum diesel with respect to brake power. From the graph the smoke of B50 and B100 is slightly higher in starting at first load condition. After that full load condition the B50 and B 100 is slightly lower than Diesel.

The formation of local rich mixture in the combustion chamber due to high viscosity of biodiesel result in poor atomization at starting load. At rated load, the smoke formation is diminished because of oxygenated nature of bio diesel that leads to complete combustion. Its result in the lower emission and smoke when compared to diesel in the full load condition.

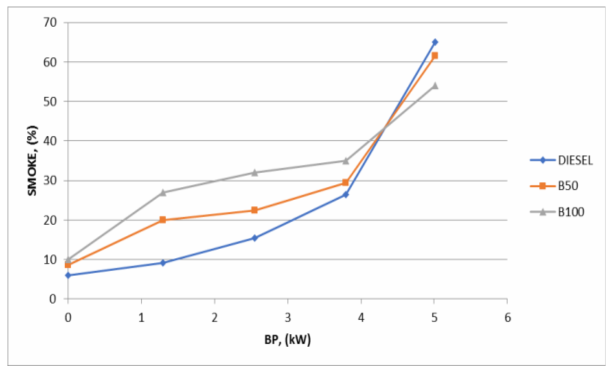

Fig 3: Smoke against brake power

b. Carbon monoxide

Carbon monoxide (CO) is the most common type of fatal air poisoning in many countries. It is colorless, odorless and tasteless, but highly toxic gas. From the graph the variation for different tested fuels with respect to brake power. The co of B50 and B100 is lesser in the starting condition of the load but in the end B50 is higher in co and diesel is slightly lower in the B50 and B100 is less emission of co.

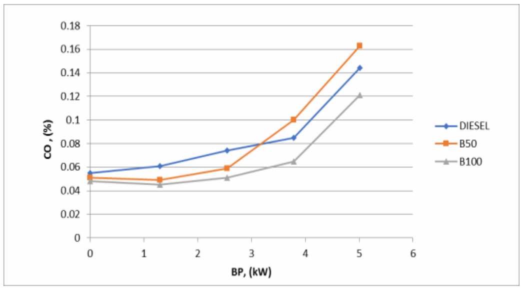

Fig 4: Carbon monoxide against brake power

c. Hydro carbon

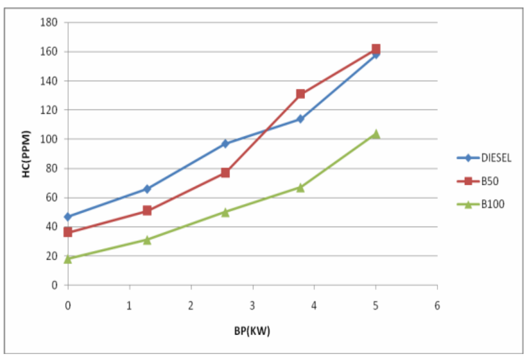

Fig 5: Hydro carbon against brake power

Hydrocarbon pollution are formed when the fuel is not completed burned. Hydrocarbon is one of the important parameters for determining the emission behavior of diesel engine. From the graph the HC rate is lesser in the starting load as well as ending load compared to diesel . B50 (50% biodiesel and 50% diesel) is higher in peak load when compared to B100 (100% biodiesel) and diesel.

d. Carbon dioxide

Carbon dioxide is the colour less with the density of 60% higher than that of dry air. Trees are intaking carbon dioxide. Carbon dioxide is the most significant long lived green house gas in earth's atmosphere. In above graph mentioned that B50 (50% biodiesel and 50% diesel), B100 (100% biodiesel), diesel has same point in initial level and in full load condition compared to diesel both B50 and B100 has higher in carbon dioxide level.

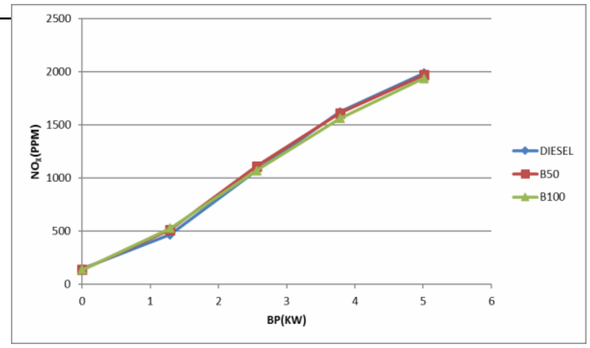

Fig 6: Carbon dioxide against brake power

e.NOx

Oxides of nitrogen emission is a generic term of nitric oxide (NO) and nitrogen dioxide (NO_2), which is produced from the reaction of nitrogen and oxygen gases in the air during combustion process. The maximum burned gas temperature, the relative concentration of oxygen and the reaction time are the critical variables for NOx formation. In this graph in initial load condition the B50 (50% biodiesel and 50% diesel), B100 (100% biodiesel),Diesel has same value but in the full load condition the NO_x emission is less in B100 when compared to B50 and diesel.

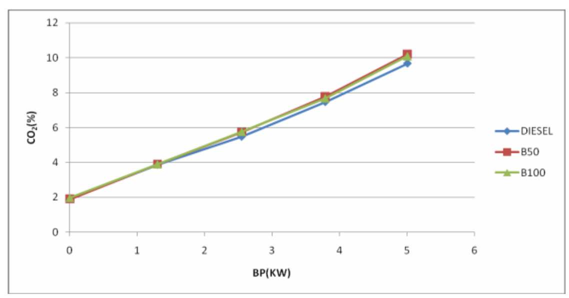

Fig 7: NO_X against brake power

VI CONCLUSION

This paper investigates about characteristics of a DI diesel engine using methyl ester of ground nut oil as a fuel and comparison of diesel and 50% of blended diesel

- *The series of experiments is conducted based on the transesterification process and the yield obtained ranges from 87% to 91% for the varying parameters.
- *Comparing to brake thermal efficiency diesel has more efficient than the B50 and B100 because its calorific value is lesser than the diesel and also viscosity and density level is higher in diesel.
- *In the emission of smoke, Biodiesel has lower calorific

value. In initial load condition biodiesel has higher smoke percentage, but in full load condition diesel has higher smoke percentage.
*According to emissions carbon monoxide, hydrocarbon, carbon dioxide B50 has higher percent of emission compare to diesel and B100.
*In the emissions of NO_x diesel has higher percent of emission compare to B50 and B100.

The test indicates about the performance and emission of biodiesel and diesel comparison in DI diesel engine.

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